

**Course Title:** Radiological Control Technician  
**Module Title:** Contamination Control  
**Module Number:** 2.05

**Objectives:**

- 2.05.01 Define the terms "removable and fixed surface contamination," state the difference between them and list common methods used to measure each.
- 2.05.02 State the components of a radiological monitoring program for contamination control and common methods used to accomplish them.
- 2.05.03 State the basic goal of a contamination control program and list actions that contribute to its success.
- 2.05.04 State the basic principles of contamination control and list examples of implementation methods.
- 2.05.05 List and describe the possible engineering control methods used for contamination control.
- 2.05.06 State the purpose of using protective clothing in contamination areas.
- 2.05.07 List the basic factors which determine protective clothing requirements for personnel protection.

**INTRODUCTION**

Contamination control is probably one of the most difficult and challenging tasks the Radiological Control Technician will encounter. To have a successful contamination control program, the radiological control staff must have considerable foresight, initiative, and experience.

**References:**

- 1. DOE-STD-1098-99, "DOE Radiological Control Standard," Articles 325, 337 and 338, 1998.
- 2. "Radiological Health Handbook," Bureau of Radiological Health, 1970.

**TYPES OF CONTAMINATION**

*2.05.01 Define the terms "removable and fixed surface contamination," state the difference between them and list common methods used to measure each.*

Contamination is simply defined as radioactive material in an unwanted location, e.g., personnel, work areas, etc. Two types of contamination are possible, fixed and removable. Fixed contamination is radioactive surface contamination that is not easily transferred to other personnel or equipment through normal contact. Removable contamination is radioactive surface contamination that is easily transferred to other personnel or equipment through normal contact.

Removable contamination is measured by a transfer test using a suitable sampling material. Common materials used for the monitoring are the standard paper disk smear or cloth smear. The standard technique involves wiping approximately 100 cm<sup>2</sup> of the surface of interest using moderate pressure. A common sampling practice used to ensure a 100 cm<sup>2</sup> sample is to wipe a 16 square inch "S" shape on the surface (i.e., 4 inches by 4 inches). Qualitative, large area wipe surveys may be taken using other materials, such as Masslin cloth or Kimwipe, to indicate the presence of removable contamination. These are commonly used when exact levels of contamination are not required.

Fixed contamination is measured by use of a direct survey technique. This technique, commonly referred to as "frisking," indicates the total contamination on a surface apparent to the detector from both fixed and removable. When non-removable levels are to be recorded, the removable level must be subtracted from the total.

**ASSESSING CONTAMINATION HAZARDS**

*2.05.02 State the components of a radiological monitoring program for contamination control and common methods used to accomplish them.*

In order to acquire the radiological information necessary for contamination control, there are several components to a radiological monitoring program. These are:

- Constant monitoring
- Area and equipment surveys
- External personnel surveys
- Personnel internal monitoring and bioassay

## Constant Monitoring

There are various types of constant monitoring instruments throughout the facilities to warn personnel of radiation and contamination hazards. Some instruments are permanently installed, and some instruments are portable to allow movement from place to place as deemed appropriate by the radiological control staff.

**Continuous air monitor (CAM).** These instruments continuously sample the air for radioactive contamination in specific locations. The air being sampled is either drawn through a moving particulate filter which is then monitored by a detector system or through an internal detector to directly identify radioactive materials present. A CAM can give both a visual and audible alarm to warn personnel of the presence of airborne contamination.

**Process monitoring systems.** Process monitoring systems monitor certain operations in various facilities to alert operators of abnormal conditions which might lead to the release of excessive amounts of radioactivity to the facility or environment.

## Area and Equipment Surveys

Area and equipment surveys are conducted routinely throughout the facilities to locate sources of radiation and contamination and to detect potential changes in radiological conditions. Pre-job surveys are performed prior to work in radiological areas in order to evaluate the hazards and determine work limitations and physical safeguards.

**Direct instrument surveys.** Various types of portable survey instrumentation are used to measure the presence of radioactive contamination on a floor or surface. This is the only method available to detect "fixed" surface contamination. It must be remembered, however, that this method will detect removable as well as "fixed" surface contamination activity. As a result, a direct survey must be combined with a "smear" survey to determine if the surface contamination present is removable or fixed.

**Smear surveys.** A disk smear is wiped over an area of 100 square centimeters and counted with proper instrumentation to determine the activity of the nuclides present. Contamination levels are specified in units of dpm/100 cm<sup>2</sup> after applying applicable instrument correction factors. For objects less than 100 cm<sup>2</sup>, the units are reported as dpm/object area. Disk smears are small so they are usually used in an area of suspected contamination. Properly applied experience will dictate to the surveyor where contamination is most likely to occur and hence those areas that should be surveyed with disk smears. Disk smears are required if contamination levels are to be quantified.

Many routine contamination surveys are taken in areas not suspected to be contaminated with a chemically treated cloth called a masslinn (paper towel, atomic swipe, etc). The cloth is lightly pushed over an area and scanned with an appropriate detector to detect the presence of contamination. If contamination is detected, a more thorough disk smear survey should be performed. These large area wipes are used only as an indication of removable surface contamination.

## External Personnel Surveys

Personnel surveys are either performed by the individual (self-monitoring) using hand-held or automated instruments or by a radiological control technician. Self-monitoring is typically performed upon exiting a contaminated area at established boundary points. Personnel monitoring by a RCT is usually conducted whenever contamination of the body or clothing is suspected, or as required by exit monitoring when self-monitoring is not feasible (remote location) or not allowed. The types of hand-held or automated instruments used for self-monitoring are generically described below.

**Personnel monitors.** Portable instruments (friskers) with sensitive hand held detectors are used by personnel to identify contamination on themselves whenever contamination is suspected. These monitors are used whenever exiting contaminated areas, Radiological Buffer Areas, and in some cases Radiological Control Areas (RCA). Geiger-Mueller (GM) detectors are most often used for beta-gamma monitoring and scintillation detectors for alpha monitoring.

**Personnel Contamination Monitors (PCM).** The PCM provides personnel with an external whole body monitoring system. The contamination detectors within the monitors are capable of performing a survey of the whole body in a period of a few seconds, dependent upon background radiation levels present in the area and the personnel contamination limit of concern. These automated systems typically provide a more reliable method of locating personnel contamination over hand-held instruments.

**Hand and Foot Monitors.** Hand and foot monitors with detachable hand-held detectors provide another alternative to using hand-held instruments (friskers). These devices can monitor the hands and feet during a period of a few seconds, again, dependent upon background radiation levels present in the area and the personnel contamination limit of concern. After the hands and feet have been monitored, the detachable hand held detectors, which are typically of a larger detector size, can be used to monitor the remainder of the body in a shorter time period than most friskers.

**Portal monitors.** The portal monitor is a "door frame" type device which provides a final monitoring point to ensure contamination is not spread outside the facility to other facilities or the general public. These type of monitors are typically used only for beta-gamma monitoring.

**Personnel surveys.** Personnel surveys are performed whenever contamination of the body or clothing is suspected, or as required for exit monitoring, e.g., when friskers or automated monitoring instruments are not available.

The whole body should be surveyed with special attention to areas which are more likely to become contaminated. Contamination of the feet (shoes) would indicate removable surface contamination on the floor just traversed. The hands are extremely prone to becoming contaminated when working directly with radioactive materials. Upon completion of work or prior to leaving the area for glovebox, laboratory fume hood,

sample station, or localized benchtop operations, a minimum survey of hands, arms, and front portions of the body must be performed.

Other body areas which are prone to contamination are the buttocks, knees, and elbows and head.

The nose and mouth should be surveyed upon discovery of any level of facial skin contamination, or if airborne contamination was detected in the workplace, since contamination in this area might indicate the need for bioassay sampling. The nose can be swabbed with Q-tips and the swab counted in a smear counter to determine a potential deposition. Contamination of the nose or mouth may indicate airborne contamination.

All open wounds must be monitored since contaminants can be readily absorbed into the body.

In addition to these specific body areas, the surveyor should pay special attention to any area of the body and/or clothing which he or she suspects might be contaminated.

Upon detecting personnel contamination, follow-up area and/or equipment surveys may be necessary to determine the source of contamination and the extent the contamination has spread, if any.

### Personnel Internal Monitoring

A routine program of internal contamination monitoring is conducted as a final check on contamination control procedures. This program consists of external whole/partial body counting and/or urinalysis.

**In-vivo Bioassay:** The individual is placed inside a array of very sensitive detectors to measure the activity and energies of gamma ray emissions from inside the body. This information can be used to determine the amount and identify the type of nuclides present. Examples include whole body, lung, or scanning bed counters.

**In vitro Bioassay:** Urine or feces samples are collected from an individual to determine the type and activity of the nuclides present in bodily waste. This information is used to approximate the amount of nuclides present in the body by their calculated rate of elimination. This method can be used to assess the presence of non-gamma emitting nuclides.

### BASIC GOAL OF CONTAMINATION CONTROL

2.05.03	<i>State the basic goal of a contamination control program and list actions that contribute to its success.</i>
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Once the presence of radioactive material has been located, the basic goal underlying any effective contamination control program is to minimize contaminated areas and maintain contamination levels as low as reasonably achievable.

In some situations, this is not always possible due to:

- Economical conditions: Cost of time and labor to decontaminate a location(s) out-weighs the hazards of the contamination present.
- Radiological conditions: Radiation dose rates or other radiological conditions present hazards which far exceed the benefits of decontamination.
- Operating conditions: Some areas, e.g., hot cells, will be contaminated due to normal operations.

Other means of control must be initiated when decontamination is not possible. Engineering control (ventilation and containment), administrative procedures (RWPs), and personnel protective equipment are alternatives for the control of contamination. In Fixed Contamination Areas the contamination may be covered by paint, floor tiles, etc. when decontamination is not possible.

"Good Housekeeping" is a prime factor in an effective contamination control program. It involves the interactions of all groups within the facility. Each individual must be dedicated to keeping "his house clean" to control the spread of contamination. Every possible effort should be made in all operations to confine the spread of radioactive materials to the smallest possible area. A sound preventive and corrective maintenance program can prevent many radioactive material releases. All material taken into or out of contaminated areas must be controlled. RCTs should always be alert for potential violations to the basic principles of contamination control.

- Use of improper contamination control methods
- Bad work practices
- Basic rule or procedure violations
- Radioactive material releases or liquid spills

## CONTAMINATION CONTROL MEASURES

Controlling the spread of contamination is probably the most difficult and challenging task the Radiological Control Technician will encounter. To have a successful contamination control program, the radiological control staff must have considerable foresight, initiative, and experience. The radiological control staff will assist line management with the basic principles of contamination control.

2.05.04	<i>State the basic principles of contamination control and list examples of implementation methods.</i>
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- Access/Administrative Controls
- Engineering Controls
- Personnel Protective Measures
- Decontamination
- Preventive Methods

### **Access/Administrative Controls**

Once contamination has been located and quantified and radiological areas have been determined, access control to these areas must be adequately established. Two basic access control points, primary and secondary, are used in contamination control.

The primary access control point in a facility is the entry and exit portal between the clean area and the radiologically controlled area or Radiological Buffer Area. The success of a control program is based on controlling the movement of personnel and equipment between these areas to prevent release of contamination to a clean location.

The secondary access control points (perhaps the most important) are set up within the Radiological Buffer Areas (RBAs) to control access between surface contaminated areas and non-contaminated areas. Yellow and magenta rope, chain, tape or similar barriers are used to identify the boundaries and provide a recognizable visual barrier to personnel. In areas of ongoing work activities, special requirements will always be established for entry and exit through these access control points. When the radiological conditions are severe, the access control point may be continuously manned by a Radiological Control Technician. It is not expected that Radiological Buffer Areas will be established around inactive or secured Contamination Areas.

Step-off pads (SOPs) identify the entry and exit points to contaminated areas when possible. The use of SOPs creates a sharp line of distinction between the surface contamination area and the clean areas. Proper procedures must be established and observed for crossing the SOP to prevent the spread of contamination. All tools and/or equipment used in a surface contamination area which are unmonitored should be placed in clean plastic bags or securely wrapped in plastic before being removed from the area. All personnel and materials exiting the area should be monitored to ensure they are free of contamination.

Radiological Buffer Areas should also be established in areas where there is a need to limit exposure to external radiation, such as Radiation, High Radiation, and Very High Radiation Areas. The boundary should be established to limit radiation dose to general employees to less than 100 mrem per year. RBAs need not be posted for external exposure control if other posted boundaries provide equivalent employee protection.

Other administrative controls used for contamination control include the use of Radiological Work Permits, routine workplace surveys that are performed in order to detect trends in the potential buildup of workplace contamination, and review of operational and maintenance procedures to ensure radiological requirements are incorporated in the daily conduct of operations.

**ENGINEERING CONTROLS**

2.05.05 *List and describe the possible engineering control methods used for contamination control.*

**Ventilation.** The design of permanent or temporary ventilation systems needs to be such that air flow is from clean areas to RCAs, to areas of moderate contamination, to areas of high contamination, and finally to an exhaust system capable of removing any contamination from the air. Slight negative pressure is typically maintained in buildings/rooms where potential contamination exists. As necessary, high efficiency particulate air (HEPA) filters are used to remove radioactive particles from the air.

**Containment.** On jobs with very high contamination potential, a plastic tent (greenhouse or hut) can be built around the work area to confine all contamination to as small an area as possible. A portable ventilation exhaust system (such as HEPAs) may be used to control air flow in the work area and remove airborne contamination. Where possible, small containment devices, such as glove boxes, glove bags, or hoods can be used to contain the contamination depending on the nature and location of the work being performed. Drums or other approved containers are also utilized.

**Bagging.** The most widely used method of containment is bagging or wrapping. Contaminated tools or equipment are placed in plastic bags, or securely wrapped in plastic, before being moved outside a contaminated area. When possible, wrapping tools or equipment prior to entry can help control contamination during use inside the contaminated area.

**Design and Control.** Design of facilities should be such that efficiency of maintenance, operations, and decontamination is maximized. Components should be selected that minimize the buildup of radioactivity. Support facilities are to be included that provides for donning and doffing of protective clothing and for personnel monitoring. Personnel traffic should be routed away from contaminated areas.

**PERSONNEL PROTECTIVE MEASURES**

2.05.06 *State the purpose of using protective clothing in contamination areas.*

If engineering control methods are not adequate, then personnel protective measures, such as protective clothing and respiratory equipment, will be used. The purpose of protective clothing is to keep contamination off the skin and clothing of the workers. Protective clothing allows personnel to work inside a contaminated area with removable contamination and to exit the area without spreading contamination to uncontrolled areas. The use of protective clothing alone will not guarantee complete elimination of personnel contamination and is not a substitute for



implementing proper controls, but if used properly, protective clothing will afford a high degree of protection.

All personnel entering contaminated areas with removable contamination will be required to wear certain items of protective clothing. The types of clothing required will vary depending upon the contamination levels and the nature of the work to be performed. Some additional factors for the selection of protective clothing include the type and form of contamination; potential for increased levels of contamination, area of the body at risk, and competing hazards, i.e., heat stress, asbestos, etc.

Some type of respiratory protective equipment will be required for work in areas where very high contamination levels exist or airborne contamination is present.

### **Decontamination**

Line management is responsible for ensuring prompt decontamination, where practical, of facilities, tools, material, and equipment so that contamination can be minimized in the workplace. Reasonable efforts should be directed toward the decontamination and unconditional release of these items rather than their disposal as radioactive waste. Only items that are extremely contaminated with risks during decontamination that out-weighs the benefit to be gained for reuse should be considered for disposal.

### **Preventive Methods**

The following are practical methods used for the prevention/control of contamination:

- Identify and repair leaks before they become a serious problem.
- Establish adequate work controls before starting jobs.
- While conducting pre-job briefs, discuss measures that will help reduce or prevent contamination spread.
- Change out gloves or protective gear as necessary to prevent cross-contamination of equipment.
- Pre-stage areas to prevent contamination spread from work activities.
- Cover piping/equipment below a work area to prevent dripping contamination onto less contaminated areas.
- Cover/tape tools or equipment used during the job to minimize decontamination after the job.
- Follow good work practices such as good housekeeping and cleaning up after jobs.

- Confine the spread of radioactive material releases by a sound preventive maintenance program.
- Control and minimize all material taken into or out of contaminated areas.

## BASIS FOR ESTABLISHING PROTECTIVE CLOTHING REQUIREMENTS

In order to prevent radioactive contamination from getting on or into the body, protective clothing requirements must be established where the potential exists.

*2.05.07 List the basic factors which determine protective clothing requirements for personnel protection.*

There are several basic factors which determines the type and extent of protective clothing required:

- type and form of contamination
- levels of contamination
- type of work being performed

Some additional factors to consider include the potential for increased levels of contamination, the area of the body at risk, and competing hazards, i.e., heat stress, asbestos, etc. Once the types of protection needed are established, the most efficient protective clothing must be selected from the different articles of protective clothing available for use.

A discussion of the controls/clothing types for specific areas of the body follows.

### Whole body protection

A lab coat provides protection from low levels of contamination and is only applicable when the potential for upper body contact with contaminated surfaces is very low. In general, lab coats are worn for hands-off tours and inspections in areas with removable contamination at levels 1 to 10 times the values in Table 2-2 of the Radiological Control Standard, or during benchtop, laboratory fume hood, sample station, and glovebox operations.

Coveralls provide protection from low to moderate levels of DRY contamination protection. Protection is low when body contact with contaminated surfaces is prolonged (since contamination can be ground into or through the cloth) and when the surface is wet. The degree of protection can be increased by use of more than one pair at a time to protect the body. Cloth coveralls are permeable, and so are not effective against radionuclides with high permeability properties (gases, tritium, etc.).

Plastics coveralls provide protection from high levels of dry contamination and wet contamination. They provide limited protection from tritium and other highly permeating radionuclides (which may be transported through coveralls to the skin surface).

Disposable coveralls, e.g., tyvek suits, provides moderate protection from radioactive contamination and are used for work involving mixed hazards, i.e., asbestos, PCBs, etc., where reuse is not desirable. Disposable coveralls can be fairly easily torn.

It should be noted that at a minimum, outer personal clothing should not be worn under protective clothing for entry into High Contamination Areas or during work conditions requiring a double set of protective clothing. Sites may choose to be more restrictive as necessary to minimize potential skin/clothing contamination.

### **Hand protection**

Surgical gloves are a minimal requirement normally used in only light contamination work areas which require a high degree of dexterity. Surgical gloves are fairly easily torn or punctured.

Rubber gloves are lightweight and provide a good gripping surface. They are normally used in moderate to heavy contamination locations. Rubber gloves have greater puncture, abrasion and solvent resistance, but afford a lower degree of dexterity than surgical gloves.

Neoprene gloves are synthetic rubber gloves mounted to various containment devices to allow access by the wearer into the device. They are used to provide protection for the wearer when working inside a containment device in which highly contaminated materials are present. They are usually of arm length attached to dry boxes, glove boxes and bags, or other cabinets and provide a gas tight seal to the structure. Gloves are normally taped to the sleeve of the lab coat, coveralls, plastic suit, etc. and are tabbed to permit easy removal.

Cotton glove liners may be worn inside standard gloves for comfort, but should not be worn alone or considered as a layer of protection.

Leather or canvas work gloves should be worn in lieu of or in addition to standard gloves for work activities requiring additional strength or abrasion resistance.

### **Foot protection**

Booties are used to protect the lower leg area below the coveralls from contamination. Different constructions used are plastic and cloth (sometimes called cloth shoe covers).

Shoe covers are worn over booties to provide a second layer of protection and provide traction to wearer. They are normally constructed of plastic or rubber, and may be taped to the pant legs of the coveralls or plastic suit depending on the level of contamination and type of job.

**Respiratory protection**

Full face masks are used to filter particulate radionuclides and/or radioactive iodine from the breathing air of the wearer when the surrounding atmosphere is not immediately dangerous to the life and health of the wearer.

Supplied air systems may prevent inhalation of particulate and gaseous nuclides by the wearer in a non-life threatening atmosphere.

A self contained breathing apparatus (SCBA) is used to provide a portable source of breathing air to the user when entering an atmosphere which may be immediately dangerous to life and health.

Medical approval, training, and fit testing are required prior to respiratory protection use. Systems should be in place to verify these criteria in the field. To ensure proper use of a respirator prior to entering areas requiring its use, the wearer should be clean shaven in the area of fit and he/she should perform fit checks of their respirators to ensure a proper seal.

**FACILITY PROTECTIVE CLOTHING REQUIREMENTS**

(Insert facility specific material here)

**SUMMARY**

All reasonable efforts must be made to control contamination in order to provide protection for workers on site and the general public from the hazards presented by radioactive material. This lesson covered the phases of a contamination monitoring program, and the goal, principles, and methods used to support the contamination control program.